

Approved by:

_____/_____/_____
Process Engineer_____/_____/_____
Equipment Engineer

1 SCOPE

The purpose of this document is to detail the use of the Advanced Semiconductor Materials (ASM) low-pressure chemical vapor deposition (LPCVD) system for deposition of silicon nitride, polycrystalline silicon and low temperature oxide (LTO) films. All users are expected to have read and understood this document. It is not a substitute for in-person training on the system and is not sufficient to qualify a user on the system. Failure to follow guidelines in this document may result in loss of privileges.

2 REFERENCE DOCUMENTS

n/a

3 DEFINITIONS

n/a

4 TOOLS AND MATERIALS

4.1 System

4.1.1 The ASM LPCVD is a two-tube system. Only one tube may be run a time because there is only one pumping system. **Poly-silicon and silicon nitride are run in the lower tube. LTO is run in the upper tube.** There are no exceptions.

4.2 Wafer Boats

4.1.1 Six wafer boats are located in the cabinet on the stainless steel bench in front of the LPCVD system. There is a four-inch and six-inch dedicated boat for each of the three processes.

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4.3 Dummy Wafers

4.2.1 Dummy wafers are located in boxes on the stainless steel bench in front of the LPCVD system.

4.4 Off-loading platform

4.3.1 The off-loading platform is located on the side of bench that faces the six-inch LPCVD system. Boat forks are located on the stainless steel bench.

4.5 Recipe Tapes

4.4.1 Recipe tapes are located in a pouch in the instruction manual.

5 SAFETY PRECAUTIONS

5.1 Hazards to the Operator

5.1.1 High Temperatures - The LPCVD is operated at high temperatures (~800 °C) and can cause skin burns and melt plastic. Do not touch the tube when it is hot.

5.1.2 Hazardous Gases - The deposition processes use dichlorosilane SiH_2Cl_2 , silane SiH_4 , ammonia NH_3 and oxygen O_2 . These gases are toxic and pyrophoric. Read material safety data sheets (SDS) and be familiar with hazards and safety controls to prevent an accident before using the system.

5.1.3 Emergencies - In the event of an emergency such as fire, gas alarm or any other serious problems, push the red **EMO** button. Two **EMO** buttons exist, one beneath the Operator's Control Panel near the tube door and one beneath the keyboard, display and tape drive panel. Immediately evacuate the area and notify a lab staff member or your lab instructor.

5.2 Hazards to the Tool

5.2.1 Contamination – No copper, gold or similar metals. No photoresist. If you are not sure if a material is allowed in the tool, ask a staff member.

5.2.2 Melting O-Rings – When at atmosphere, the front door should not be closed until the tube temperature in the front zone is less than 400°C. Failure to do so will damage the o-rings and prevent adequate vacuum from being achieved.

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- 5.2.3 Remove Tape after Loading – After loading a recipe from the tape, remove the tape from the drive. If an error occurs during the run, this will prevent the tape from being corrupted.
- 5.2.4 Failure to Load the Temperature Initialization Tape – The Temperature Initialization Tape must be loaded before turning on the element to prevent thermal run-away.
- 5.2.5 Failure to Monitor the Process – Do not leave the tool unattended during operation. During the process the user should monitor the tube pressure, temperatures and gas flows. If there is a large deviation from the recipe, consult a staff member.

6 INSTRUCTIONS

6.1 Before you begin:

- 6.1.1 Fill out a yellow, “Equipment in Use Notice” and place it on the clip at the top of the load end of the furnace. Failure to do so could result in the furnace, burnbox or gas cabinet being shut off during your run.
- 6.1.2 Fill out log sheets for your process on the side of the system.
- 6.1.3 Do not begin a run if you will not finish by 5 PM. Gas lines are no longer pumped out at the end of the run.
- 6.1.4 The tube doors are closed during down time for cleanliness. Open the tube doors before turning on the heating elements and leave open until the tube is cool. If the tube is still hot at the end of the day, leave the tube door open.

6.2 Starting the system

- 6.2.1 Swipe the tool in on the cardswipe. An alarm will sound as the system powers on.
- 6.2.2 Both SATCs should be on. Press the reset buttons above both SATCs.

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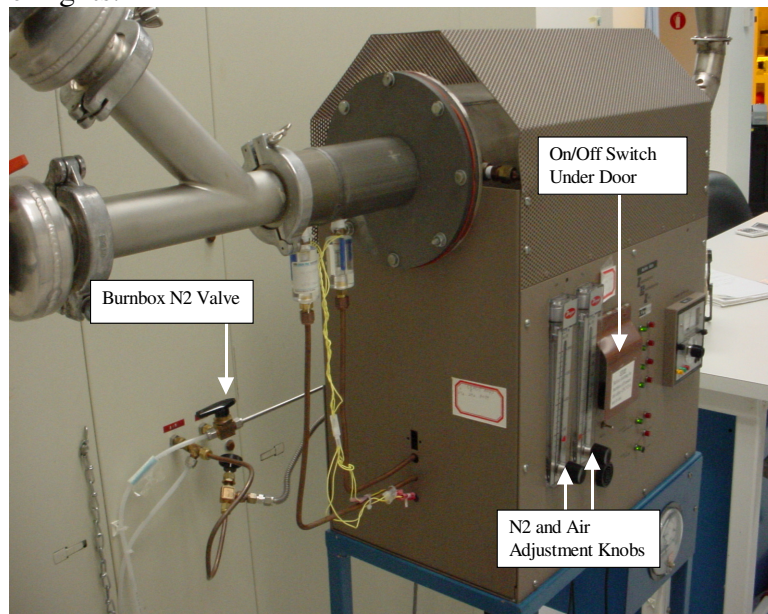
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6.2.3 Check the DOD Toxic Gas Monitor in the back hall to ensure it is operational and that the building override switch is **OFF**. Check that the N₂ latch in the red box mounted on the wall is enabled as well. The yellow lamp in the Red Gas Control box must be on.

6.2.4 Turn on the **Burnbox N₂** (black handled valve behind the burnbox) and then turn on the **Burnbox Power** with the button under the brown cover. This should light the front panel lights.



6.2.5 On the gas cabinet pressure panel ensure the regulators for **N₂ and O₂** have **at least 40 psi**. These are located in the back of the furnace. A window has been added to allow you to see these gages without opening the door.

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N2 and O2
Gages

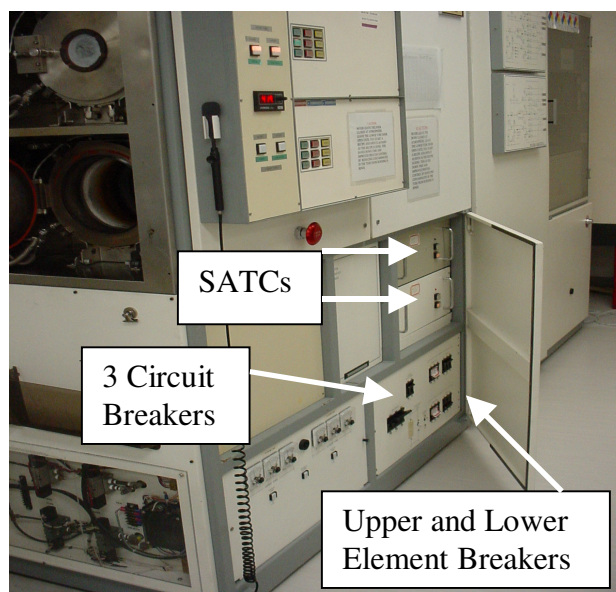
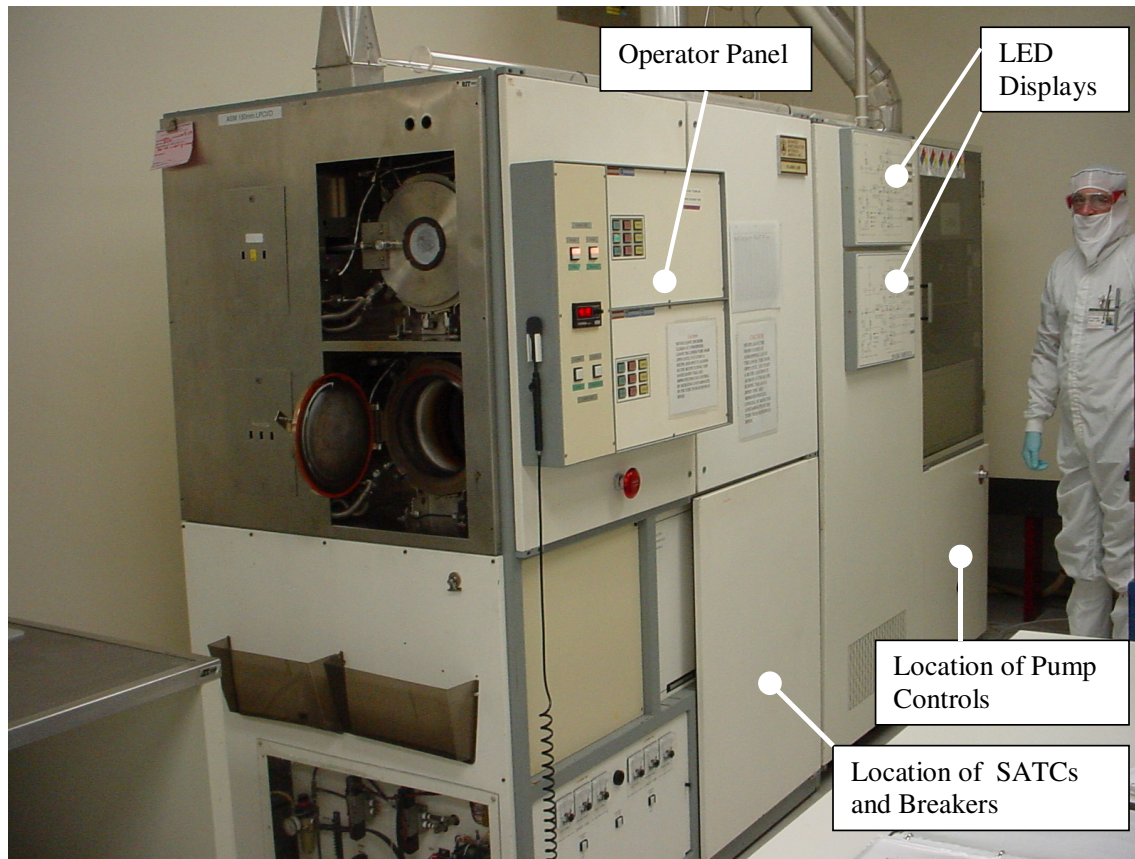
Process Gasses

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- 6.2.6 Ensure the pump package is running. If there is a problem call a staff member.
- 6.2.7 On the Keyboard, Display and Tape Drive Panel turn the **rotary switch** to the appropriate tube (upper or lower). The main menu should be displayed. **Do not switch the rotary switch while the recipe is running. This will turn off the vacuum pumps and cause the recipe to abort.**
- 6.2.8 Login to the system
 - 6.2.8.1 Type **16** and press **RETURN**
 - 6.2.8.2 Type the password, 53 followed by thirteen zeros (i.e.: **5300000000000000**) and press **RETURN**. The bottom of the screen should flash SYSTEM USER LOGGED ON.
- 6.2.9 Initialize temperature controls (**MUST BE DONE BEFORE STEP 6.2.10**)
 - 6.2.9.1 Load the **Temperature Initialization Tape** with the label on the tape toward you and close the tape drive door. One side of the tape is for 4-inch wafers and the other side is for 6-inch wafers.
 - 6.2.9.2 Type **14 “CASSETTE RECORDER”** and press **RETURN**.
 - 6.2.9.3 Type **1 “READ”** and press **RETURN** under DEFINE ACTION.
 - 6.2.9.4 Type **2 “TABLE”** and press **RETURN** under DEFINE DATA TYPE.
 - 6.2.9.5 Type **Y** and **RETURN** at the prompt “READ SPIKE TC CAL. TABLE”.
 - 6.2.9.6 Type **Y** and **RETURN** at the prompt “READ CAL. TC DEV. TABLE”.
 - 6.2.9.7 Type **Y** and **RETURN** at the prompt “READ PID CONSTANTS TABLE”.
 - 6.2.9.8 Type **Y** and **RETURN** at the prompt “ARE YOU SURE THIS MUST BE READ?”
 - 6.2.9.9 After the tape is read press **RETURN** to continue and remove the tape.
- 6.2.10 Wipe the O-ring on the door and the sealing surface with some IPA. Use caution since the system may still be hot from a previous run.

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6.2.11 Turn on the **Element Circuit Breaker** for the appropriate tube (upper or lower).

6.3 Load and Edit Recipe

6.3.1 Insert the tape for the process you wish to run with the label on the tape toward you and close the tape drive door.

6.3.2 Type **5 “LOAD TAPE RECIPE”** and press **RETURN**

6.3.3 At the prompt asking “Are You Sure?” type **Y** and press **RETURN**. The tape should start spinning as the recipe is loaded. Once the tape stops the screen should say **FUNCTION COMPLETED**. Press **RETURN** to return to the main menu.

6.3.4 Remove the tape from the tape drive.

6.3.5 Edit the recipe time

6.3.5.1 The deposition time is the only parameter that needs to be edited for normal operation. The deposition time determines the film thickness. Deposition time should be calculated from recent deposition rates as recorded on the log sheet. Ensure the rate used to determine the time is from the same process and wafer size as the one intended to be run.

6.3.5.2 Type **8 “RECIPE EDITOR”** and press **RETURN**.

6.3.5.3 Type **2 “EDIT ANY STEP”** and press **RETURN**.

6.3.5.4 **The deposition step for all processes is step 44.** Type **44** and press **RETURN**.

6.3.5.5 Type **2 “TIME”** and press **RETURN**.

6.3.5.6 **Enter the desired deposition time** and press **RETURN**. The time must be in the format **hh:mm:ss** (with colons included). Press **RETURN twice** to return to the main menu.

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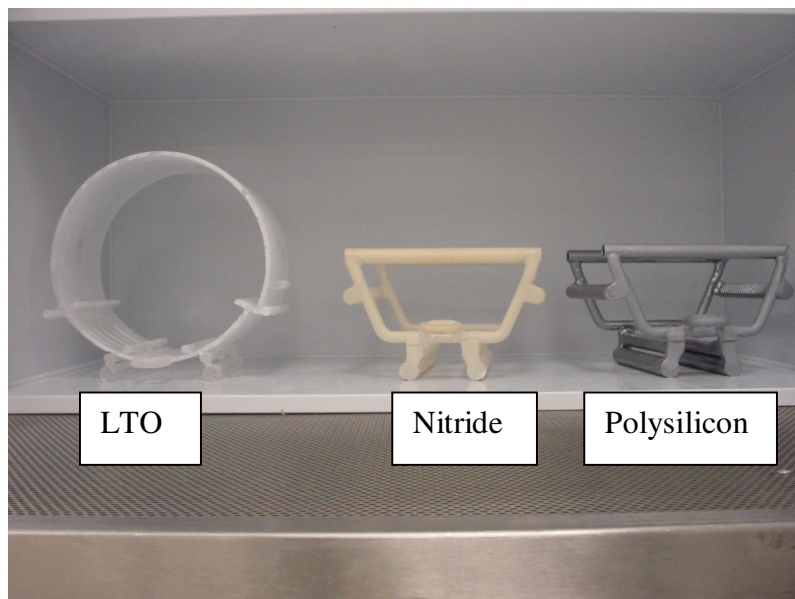
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6.4 Load wafers into tube

- 6.4.1 Load the wafers into the boat. Device wafers should be loaded in the center of the boat. All remaining spaces should be filled with dummy wafers. The poly and nitride boats are loaded with all wafers facing the front of the tube. The LTO boat is loaded with the wafers in pairs. The pairs should be placed back to back. For LTO, the deposition rate on the backs will be much lower than the fronts.



- 6.4.2 To load the wafer boat into the lower tube, mount the **off-loading platform**. **Inserting the platform disables the door with the micro-switch in the left mount hole to prevent knocking the boat of wafers off during load/unload.** For the upper tube, use the appropriate boat fork.
- 6.4.3 Use the quartz rod to push the wafer boat to the stop at the center of the tube. The red line on the rod should line up with the door to the tube.

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6.5 Starting a Run

- 6.5.1 Once the burn box is at temperature ($>550^{\circ}\text{C}$) the AIR interlock turns green and air will flow. **Adjust** the **N₂** and **air** to the marks on the flow meters.
- 6.5.2 On the computer from the Main Menu, type **2 “Input Status Display”** and press **RETURN**. At the prompt asking for “**Corrected T.C. Readings,**” type **Y**. Temperatures, pressures, gas flows, current step and remaining recipe time can all be monitored.
- 6.5.3 On the computer, verify that the temperatures have stabilized at 380°C . They may overshoot and then come back to 380°C . If the run is started before the temperatures have stabilized, the tool will alarm.
- 6.5.4 On the Operator and Door Control Panel for the appropriate tube, press **CLOSE** followed by **LATCH**. **Do not close the door unless you are ready to start the recipe.**
- 6.5.5 On the Operator and Door Control Panel Press **RECIPE 1**, **RESET**, and **RUN** to begin the run.
- 6.5.6 The system will likely fail the leak check (step 4) due to out-gassing in the tube. If the system fails, an alarm will sound and the system will automatically return to the previous pump down step. Press **ALARM** to silence the alarm and let the tube pump down and re-try the leak check.
 - 6.5.7 After the run passes the leak check (step 4), use the key on the CVD key ring **turn on only the gases needed** for the specific process you are running. These controls are in the red box mounted on the wall toward the maintenance room. **The new gas lines are installed and the lines will remain charged continuously. The switches will open the source valves and ensure the process doesn’t run out of gas. (ENSURE THE LIGHT IN THE RED BOX REMAINS ON WHEN THE GASSES ARE TURNED ON)** Contact staff immediately if the light goes out.
- 6.5.8 The system will run automatically and perform the deposition. **Do not leave the machine unattended during operation.**

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6.5.9 The parameters required to be filled out on the log sheets are

6.5.9.1 Base Pressure – this is the **MKSTUBE** number displayed at the end of Step 3
PMP_DWN1

6.5.9.2 Temperature – Record the profile temperature (°C) in each of the three zones during the deposition step. 1, 2 and 3 are for the lower tube and 4, 5 and 6 for the upper. Profile readout is on the Operator Panel.

6.5.9.3 Gas Flow – Record the gas flow (sccm) for each of the process gases during the deposition step.

6.5.9.4 Dep. Pressure – Record the **MKS TUBE range** displayed during the deposition step.

6.5.10 When the recipe reaches **Step 45**, you may turn off the gases. Make sure that nobody is using the same gases on the P-5000.

6.5.11 See Appendix A for further process information.

6.6 Ending a run and unloading the tube

6.6.1 Once a recipe has been completed, the tube is automatically returned to atmospheric pressure and the alarm sounds. Press the **ALARM** button to silence the alarm. The heaters return to idle temperature, 380 °C. **Do not touch the tube while it is hot!**
Immediately unlatch and open the door to prevent the O-rings from burning.

6.6.2 On the Operator and Door Control Panel for the appropriate tube and press the **UNLATCH** button, followed by the **OPEN** button.

6.6.3 Using hot work gloves and a pull rod, slowly pull the wafer boat from the tube.

6.6.4 To remove the wafers from the lower tube mount the **off-loading platform**.
Doors are disabled while platform is installed. For the upper tube, use the boat fork.

6.6.5 Place the wafer boat on the quartz plate to cool.

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6.6.6 Remove the off loading platform from the furnace.

6.6.7 Allow the tube to cool with the door open.

6.7 Ending a run

6.7.1 Leave the tube door open.

6.7.2 Turn off the gasses for your recipe if the PECVD are not using them with the switches in the red box.

6.8 Final shutdown

6.8.1 Turn off the **heater circuit breaker** for the appropriate tube. *All other breakers should be left on.*

6.8.2 Turn off the burn box and the burn box N₂ valve.

6.8.3 Swipe the tool out on the cardswipe system.

6.9 Problems during a run

6.9.1 If an alarm sounds, press the **ALARM** button and check the display. If the screen shows "END" in the step name you have completed your deposition.

6.9.2 If the recipe has not finished, press **RETURN** to go to the main menu. Type **13 "CHECK ERROR FILE"** and press **RETURN**. Type **"SHOW ERROR ON SCREEN"** and press **RETURN**.

6.9.3 The display now shows any errors that have occurred. If there is an error in the file, write the exact wording down and contact a technician immediately before going on. Depending on the error that has occurred, the machine may abort the recipe and shut down. If this happens the error message will be lost.

7 ATTACHMENTS

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7.1 Process Information

- 7.1.1 The upper tube display is accurate for those parameters which are active. Values appearing on all other parameters are noise (i.e. during a pump down, the display may indicate NH_3 is flowing at 50 sccm. This is noise. However, the pressure reading is correct).
- 7.1.2 The computer has not been updated to the current actual MFC size. Therefore a calibration factor is required to determine the actual flow from the displayed value. The calibration factors are:
- Lower Tube**
- SiH_2Cl_2 : .375 x indicated value
 - NH_3 : 0.8x
 - SiH_4 : 2x
- Upper Tube**
- SiH_4 : 2x
 - O_2 : 2/3 of indicated value

REVISION RECORD

Summary of Changes	Originator	Rev/Date
Original Issue	Peterson	A 4/12/02
Corrections, updated recipe table	O'Brien	B 11/27/02
Added upper resident TC's	Tolleson	C 12-13-02
	Tolleson	D
Revised 6.4 and 6.5 to turn on gasses after the leak check	O'Brien	E 04/07/03
Revised 6.5.5 for max flow switch change to delivery system	Tolleson	F 01/06/04
Revised 6.2.9 Initialization of temperature controls	O'Brien	G 03/15/04
Added 6.2.1 to cardswipe, removed sections on checking breakers and pump controls, changed setup to streamline process, added sections about P5000	O'Brien	H 05/07/2008
Modified 6.2.7 do not move rotary switch after run has started	O'Brien	I 02/05/2009
Added note about offload tray disabling doors when installed, updated MFC multiplication factors for display verses actual values	Tolleson	J 07/22/2013

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Added 6.1.4 open the tube door note and amended 6.1.3 for time management	Tolleson	K 02/10/2017
Changed the MDA reference to the DOD reference and added the window for N2 and O2 without opening the door. Change to the gas flow multipliers for NH3	Tolleson	L 04/05/2017
Eliminated pumping out the gas lines and holding in the excess flow switch buttons.	Tolleson	M 01/28/2020